# Contribution of Breeding and Genetics to increased sustainable aquaculture production in the EU - input to Horizon Europe from the R&D and industry sectors

*This aim of this document is to give input to important research topics within the field of aquaculture breeding and genetics for Horizon Europe. Aquaculture Breeding and Genetics can contribute to efficient and sustainable aquaculture in Europe by genetically improving the stocks that are produced in the EU for important traits. This is done by combining high-tech (genomic) technology and biological knowledge of the chosen species with economics and social science.*

Seafood is part of a healthy diet, containing essential amino acids and minerals and some species contain high levels of specific nutrients such as omega-3 fatty acids. EU registered a self-sufficiency ratio of 41,7% for fisheries and aquaculture product (EUMOFA, 2018). However, seafood consumer preferences vary greatly within the EU between consumer groups based on their nationality, age group, economic capacity etc. With stagnating catch from the wild fisheries, aquaculture is the sector that can fill the gap between seafood sustainable consumption and production in the EU, providing jobs in coastal and isolated areas and preserving our seas.

The main parts of the aquaculture value system are feed production, broodstock production, farming and retailers. Genetic improvement of broodstock through selective breeding is one of the most important drivers of long-term changes in aquaculture. Accumulated genetic progress of 5-10 percent per generation in the growth of fish explains a major part of the increased production of the aquaculture species with breeding programmes, while preserving the environment through e.g. improved feed efficiency. Also, other traits are improved like health and product quality, and welfare. Structural changes in the sector and more knowledge have increased the use of genetically improved stocks and the technological level of the breeding programmes. However, still, the technological level differs largely for different species and countries.


Selective breeding in aquaculture has a clear contribution to at least six of the UN sustainability goals:

***Goal 2*** - *Zero hunger* and ***Goal 3***- *Good health and well-being*: These goals manifest both hunger and malnutrition. Here, aquaculture, including selective breeding, has a major role in producing food with high overall nutritional value and with desirable/essential nutrients.

***Goal 1*** - *No poverty* and ***Goal 8*** - *Decent work and economic growth:* The aquaculture breeding and genetics sector maintain and improve economic development and decent revenues to the population living in the coastal and remote areas.

***Goal 12*** - *Responsible consumption and production* and ***Goal 13*** - *Climate action* and ***Goal 6*** - *Clean water and sanitation*: These goals are about doing more and better with less and careful management of our natural resources. Increased feed efficiency on current and future feed resources is a good example where selective breeding is important. Feed efficient fish is generally also water and energy efficient, because of reduced production time and reduced feed requirements. Increased aquaculture production in the EU reduces the unnecessary transportation of food.

***Goal 14*** - *Conserve and sustainably use the oceans, seas and marine resources* and ***Goal 15****: Life above land* cover biodiversity issues and management of genetic resources. For aquaculture, this means management of many species. It must be noted that aquaculture is the only animal production system where farmed individuals can survive into the wild, which adds an extra component of management of escapees of farmed specimens into the wild.

The European aquaculture sector is extremely diverse with respect to e.g. business ownership (family vs. multinational companies), species in culture (marine and freshwater fish, crustaceans, mussels, seaweed etc), national regulations etc. Hence, careful consideration regarding focus areas for aquaculture production and corresponding research is needed. The main challenge for European aquaculture is to exploit aquaculture production within the diverse biological and legislative limitations of the sector limitations in a sustainable way. The EATiP predicts increases of European aquaculture by 2030 of >100% for cold water marine fish and Mediterranean species, >40% for freshwater fish and >30% for shellfish.

**Aquaculture genetics and breeding** are a part of the solution to increase sustainability in aquaculture production in the EU. Researchers involved in the FISHBOOST H2020 project, co-funded by the EC, and members of the Farm Animal Breeding and Reproduction Technology Platform (FABRE TP) have participated together to draw the answers to the challenges of the European aquaculture sector in the next years.

## How research can answer to challenges of European Aquaculture sector

### a. *Most important traits for a more sustainable aquaculture breeding*

The top four groups of traits cover diseases resistance, better use of resources and nutritional aspects of aquaculture products.

- Disease resistance - estimate heritability for the traits, understanding the genetic background to disease resistance mechanisms. Epidemiological modelling of disease outbreaks.
- Feed efficiency.
- Product quality - malformations, fat content, omega-3 fatty acids and pigmentation

Traits related to animal welfare are also mentioned. These traits are currently poorly that need to be better defined in aquaculture breeding.

For all these traits, estimates of heritability and relationships to other traits, improved and high-precision phenotyping methods, gene mapping and transcriptomic analysis are needed.

### b. *Prioritising species*

A balance is needed for the prioritisation between the current species in culture and emerging species. For selected emerging species (e.g. low trophic species and crustaceans), multi-disciplinary long term strategic collaborative industry-RTD plans are needed. The next European research programme should take into account both types.

### c. *Genomics infrastructure and know-how*

- ***Genomic selection***. Further improvement of the genomic selection technology is needed for high- and low genetic marker densities. The focus should be on industry applications of genomic selection; a selection tool that results in more accurate selection of parents.
- ***Genomic resources.*** For most of the species in European aquaculture, the genomic resources are of low quality. Reference genomes, high and low genotyping techniques, and functional annotation, and general characterization (genome-wide recombination rates) of the genomes are needed.
- ***Technologies***. Micro tagging can increase early identification of fish. Development of high precision and large-scale phenotyping methods for important traits in the breeding goals, i.e. phenomics, is needed to make use of the increased precision of the genomic information.
- ***New Breeding Techniques***. New Breeding Techniques, e.g. CrispR, are very promising as tools for research and they also have the potential for industrial applications, both as a complement to traditional selection methods and as a stand-alone selection method.

### d. *Sustainability of European Aquaculture sector*

- *Climate change.* Tolerance to temperature changes of aquaculture species. Increased water temperature variation and changed water quality (oxygen, acidification of seas) of European aquaculture species is largely unknown. The effects of climate change on genetic improvement and on the genetic diversity of the wild stocks that we get our breeding populations from are also unknown.

FABRE TP
Rue de Treves 61, 1040 Brussels
Ana.granados@effab.info
email: fabretp@fabretp.info, website: www.fabretp.info

- *Environmental footprint.* Important traits to select for to reduce the environmental footprint of aquaculture production are e.g. feed efficiency (including single feed nutrients) and waste production.
- *Genetic diversity*. Genetic diversity of the European aquaculture species is largely unknown. Knowledge of the effect of introgression of farmed specimens on wild stocks and legislation of this is also largely unknown.
- *Reproduction*. Production of sterile individuals is important to reduce the effects of farmed escapees on wild populations.
- *Social science.* RRI is needed especially for New Breeding Techniques, e.g. CRISPR. Rules and laws around patenting must be effective in both supporting and protecting industry development.
- *Economics.* Business plans for local and global breeding plans are needed. These should include effects of trait improvement at the farmer, sector and society level.

***e. Kinds of projects that could answer to these needs***

- *Complementary fields.* Increased biological knowledge in complementary fields will increase the precision of both fields. For example, genetics and health, genetics and nutrition and genetics and management. Topics on nutritional programming, epigenetic effects of nutrition, genetic x vaccination effects and genetics x feed interaction were mentioned. It is also largely unknown how individuals with different genetic background perform in the emerging production systems (e.g. RAS) and co-evolution of the fish stocks and farm production systems.
- *Project types.* Both basic and applied science are seen as important, as did also collaborative research between Industry and RTD. Focused calls are needed as small follow-up projects of large projects.
- *Demonstration projects.* LCA analysis and calculations of economic and environmental impacts.
- *Collaboration outside Europe.* Collaboration with countries in Asia (China and Japan were mentioned) and Africa is important, and America (where important countries are contributing to the world production of fish and shrimp, like Chile and Ecuador, respectively)